

THIN FILM DEPOSITION APPARATUS FOR SEMICONDUCTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a thin film deposition apparatus for a semiconductor, and more particularly, to a semiconductor thin film deposition apparatus which can deposit a thin film, for example, an aluminum oxide film, on a wafer using ozone and also perform thermal treatment using ozone.

2. Description of the Related Art

General thin film deposition apparatuses for depositing a thin film on a wafer use deionized (DI) water vapor as a reaction gas for oxidation. For example, an aluminum oxide film can be formed at a thickness of an atomic layer by continuously introducing DI water vapor and TriMethylAluminum (TMA) gas into a reactor on which a wafer is loaded, and subsequently purging the introduced DI water vapor and TMA reaction gas.

However, when DI water vapor is used, an O-H group exists within a thin film, for example, an aluminum oxide film, formed by a thin film deposition process or by thermal treatment, thus degrading the characteristics of the thin film. That is, H existing in the thin film causes damage to the thin film, thereby degrading the characteristics of the thin film.

SUMMARY OF THE INVENTION

To solve the above problem, an objective of the present invention is to provide a semiconductor thin film deposition apparatus in which the use of ozone as a reaction gas for oxidation prevents defects from being generated within a thin film deposited on a wafer.

To achieve the above objective, the present invention provides a semiconductor thin film deposition apparatus having at least one reactor in which a wafer is received, a

excessive amount of ozone is generated by the ozone generator 310.

The ozone transfer unit 330, for guiding ozone generated by the ozone generator 310 to the reactor 100, is designed so that ozone used in a thin film deposition process for a wafer received within the reactor 100 is transferred separately from ozone used in thermal treatment on the wafer. That is, the ozone transfer unit 330 is connected to the main valve 320 in parallel, and includes a process ozone transfer member for transferring ozone used for a thin film deposition process, a thermal treatment ozone transfer member for transferring ozone used for thermal treatment. A selection transfer member 339 selectively transfers ozone which has passed through the process ozone transfer member or thermal treatment ozone transfer member, to the reactor 100 or exhaust pump 200. In FIG. 1, two ozone transfer units are shown. However, the other transfer unit will not be described because it has the same structure as the above-described ozone transfer unit 330. If several ozone transfer units described above are used, an equal number of reactors can be operated.

The process ozone transfer member is made up of a first process valve 332, a process mass flow controller (MFC1), and a second process valve 334, which are sequentially connected.

The thermal treatment ozone transfer member is made up of a first thermal treatment valve 336, a thermal treatment mass flow controller (MFC2), and a second thermal treatment valve 338, which are sequentially connected.

The selection transfer member 339 is made up of a first selection valve 339a and a second selection valve 339b. The first selection valve 339a is connected to a line between the second process valve 334 and the second thermal treatment valve 338, and the reactor 100, and allows or blocks the flow of ozone to the reactor 100. The second selection valve 339b is connected to a line between the second process valve 334 and the second thermal treatment valve 338, and the exhaust pump 200, and allows or blocks the flow of ozone to the exhaust pump 200. If the second selection valve 339b is opened, ozone which has passed through the second process valve 334 and the second thermal treatment valve 338 is applied to the exhaust pump 200. The

first and second selection valves 339a and 339b perform opposite operations at the same time. That is, when the first selection valve 339a is turned off, the second selection valve 339b is turned on, and vice versa.

The process MFC1 and the thermal treatment MFC2 control the flow of ozone. The process MFC1 controls the flow of ozone used in a thin film deposition process in a range of 100 to 500 sccm (standard cc/min). The thermal treatment MFC2 controls the flow of ozone used for thermal treatment up to 20000 sccm.

It is not easy to control the amount of ozone generated by the ozone generator 310 in the exact amount actually used in a thin film deposition process or thermal treatment. In practice, a small amount of ozone is used in a deposition process or thermal treatment process. However, the ozone generator 310 generally generates an excessive amount. Thus, a high ozone pressure is applied to a line connected between the ozone generator 310 and the main valve 320. When an excessive ozone pressure is applied to the line, even the MFC1 and MFC2 cannot properly control the flow of ozone. In this case, the ozone control unit 340 is operated.

The ozone control unit 340 includes an automatic pressure valve 341 and an ozone remover 342 which are installed on the line between the main valve 320 and the ozone generator 310. The automatic pressure valve 341 is automatically opened when the ozone pressure is equal to or greater than a predetermined value, and the ozone remover 342 removes ozone which has passed through the automatic pressure valve 341. For example, the ozone remover 342 can be a catalyzer that converts harmful ozone to harmless oxygen or another gas through a catalyzed chemical reaction and then exhausts the resultant gas. The ozone control unit 340 further includes a valve 345 and a check valve 344 which are installed on the line between the main valve 320 and the ozone remover 342. The valve 345 allows/blocks the flow of ozone, and the check valve 344 allows ozone having a predetermined pressure or greater to flow only toward the ozone remover 342.

When an excessive ozone pressure is applied to the line due to an increase in the amount of ozone generated by the ozone generator 310, the pressure is fed back to

operate the ozone control unit 340. That is, when the ozone pressure is equal to or greater than a predetermined value, the pressure valve 341 is opened, so that a superfluous amount of ozone flows toward the ozone remover 342. Also, in the ozone remover 342, the introduced ozone is converted into harmless gas by a catalyst, and then the harmless gas is exhausted.

The ozone control unit 340 can maintain the pressure of ozone flowing into the ozone transfer unit 330 to be uniform, and thus can guide ozone at a stable state.

In the ozone supply portion, ozone generated by the ozone generator 310 flows into the reactor 100 along a route starting from the main valve 320 to the first process valve 332, to the process MFC1, to the second process valve 334, to the first selection valve 339a, or along a route starting from the main valve 320 to the first thermal treatment valve 336, to the thermal treatment MFC2, to the second thermal treatment valve 338, to the first selection valve 339a. That is, ozone can be selectively allowed to flow into the reactor 100 by selectively turning on or off the first process valve 332 or the first thermal treatment valve 336. The first and second selection valves 339a and 339b perform opposite operations at the same time, so that when the first selection valve 339a is turned off, the second selection valve 339b is turned on. Hence, ozone is exhausted directly to the outside by the exhaust pump 200.

The gas supply portion 400 includes a first reaction gas supply unit 410 for supplying a first reaction gas to the reactor 100, a second reaction gas supply unit 420 for supplying a second reaction gas, and an inert gas supply unit 430 for supplying an inert gas used as a carrier gas or a purging gas.

The first and second reaction gas supply units 410 and 420, and the inert gas supply unit 430 are connected to each other by a pipe line, and several valves 411, 412, 413, 414, 415, 421, 422, 423, 424 and 425 are installed on the line. These valves are connected to a controller (not shown) to allow/block the flow of gas.

The first reaction gas supply unit 410 includes a first reaction material container 416 filled with a first liquid reaction material to be vaporized and used as a first reaction gas, a mass flow controller (MFC) for controlling the flow of a carrier gas for transferring

the first reaction gas to the reactor 100, a first flow control valve 412a installed between the first reaction material container 416 and a valve 412, and a second flow control valve 414a installed between the MFC and the valve 414. The first and second flow control valves 412a and 414a consecutively control the flow of gas, and uniformly raise/maintain the vapor pressure of a gas introduced into the reactor 100. In this embodiment, argon is used as the inert carrier gas. However, various inert gases such as neon can be used instead of argon.

The second reaction gas supply unit 420 includes a second reaction material container 426 filled with a second liquid reaction material to be vaporized and used as a second reaction gas, an MFC for controlling the flow of a carrier gas for transferring the second reaction gas to the reactor 100, a first flow control valve 422a installed between the second reaction material container 426 and the valve 422, and a second flow control valve 424a installed between the MFC and the valve 424. The first and second flow control valves 422a and 424a consecutively control the flow of gas, and uniformly raise/maintain the vapor pressure of a gas introduced into the reactor 100.

It is preferable that the first and second flow control valves 412a, 414a, 422a and 424a adopted in the first and second gas supply units 410 and 420 are meter valves or control valves. It is also preferable that the first and second flow control valves 412a, 414a, 422a and 424a are installed in front of the valves 412, 414, 422 and 424, and that the distance between a flow control valve and an adjacent valve is minimized in order to control the flow of gas at a stable constant pressure. The flow control valves 412a, 414a, 422a and 424a control the flow of gas by adjusting the cross-sectional area through which gas passes.

In the gas supply portion 400, if the valves 411, 412 and 413 are opened, a transfer gas introduced via a first supply line 41 and the valve 411 flows into the reactor 100 via a route from the flow control valve 412a, to the valves 412 and 413, to a reactor line 45, together with the first reaction gas of the first reaction material container 416.

Then, if the valves 414 and 415 are opened, a carrier gas introduced via the first supply line 41 is exhausted to the outside through a route from the second flow control

valve 414a, to the valves 414 and 415, to an exhaust line 46, to the exhaust pump 200.

The first and second flow control valves 412a and 414a consecutively control the flow of gas, uniformly raise/maintain the vapor pressure of a gas flowing into the reactor 100, and equalize the pressure of a gas applied to the reactor 100 with the pressure of a gas applied to the exhaust pump 200.

Next, an inert gas flows into the reactor 100 along a route from the valve 431 to the valve 432 to the reactor line 45, and exhausts a reaction gas that remains within the reactor 100.

Thereafter, the second reaction gas of the second reaction material container 426 is allowed to flow into the reactor 100 via a route from the first flow amount control valve 422a, to the valves 422 and 423, to the reactor line 45, along with the carrier gas introduced via a second supply line 42 and the valve 421. Then, if the valves 424 and 425 are opened, the carrier gas is exhausted to the outside via the route from the second flow amount control valve 424a, to the valves 424 and 425, to the exhaust line 46, to the exhaust pump 200. The first and second flow control valves 422a and 424a consecutively control the flow of gas, uniformly raise/maintain the vapor pressure of a gas flowing into the reactor 100, and equalize the pressure of a gas applied to the reactor 100 with the pressure of a gas applied to the exhaust pump 200.

An inert gas flows into the reactor 100 along a route from the valve 431 to the valve 432 to the reactor line 45, and exhausts a reaction gas that remains within the reactor 100.

In this embodiment as shown in FIG. 1, two ozone transfer units are shown, and three reaction gas supply units are shown. However, only the ozone transfer unit 330 and two reaction gas supply units 410 and 420 have been described to simplify explanation.

Referring to FIG. 1, the operation of the semiconductor thin film deposition apparatus is described for forming an aluminum oxide layer as an example of a thin film. Thermal treatment using ozone is performed as a pre-process for easily depositing a thin film on a wafer. In the thermal treatment, the internal temperature of

the reactor 100 is increased to a range of 300 to 700 °C, and ozone is supplied into the reactor 100. According to this thermal treatment, ozone generated by the ozone generator 310 is introduced into the reactor 100 via a route from the main valve 320, to the first thermal treatment valve 336, to the thermal treatment MFC2, to the second thermal treatment valve 338, and to the first selection valve 339a. It is preferable that the thermal treatment is performed at a temperature as high as possible to accelerate decomposition of ozone.

After the thermal treatment is performed, ozone and a reaction gas flow into a reactor at the same time or a time interval apart, in order to deposit an aluminum oxide film on a wafer. That is, ozone generated by the ozone generator 310 flows into the reactor 100 via a route from the main valve 320, to the first process valve 332, to the process MFC1, to the second process valve 334, and to the selection valve 339a. Meanwhile, the first reaction gas of the first reaction material container 416 flows into the reactor 100 via a route from the flow control valve 412a, to the valves 412 and 413, and to the reactor line 45 along with a carrier gas introduced via the first supply line 41 and the valve 411, as the valves 411, 412 and 413 are opened. The ozone and the first reaction gas flowing into the reactor 100 react with each other, so that an aluminum oxide film is deposited on the wafer.

Next, in order to purge the reactor 100, an inert gas flows into the reactor 100 via a route from the valve 431, to the valve 432 and to the reactor line 45 to exhaust the ozone and first reaction gas within the reactor 100.

Following this, a thin film deposition process is continuously performed by supplying the second reaction gas of the second reaction material container 426, together with ozone, into the reactor 100 through a similar operation to that described above. A thin film can be deposited at a thickness of an atomic layer by varying the inflow duration of a reaction gas or ozone. Also, an inert gas for purging is allowed to flow into the reactor between the times for introducing ozone and a reaction gas.

When a predetermined thin film is deposited on a wafer, the internal temperature of the reactor is increased to a range of 300 to 700 °C, and ozone is supplied into the

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